

Claims

1. System for influencing the induction gas temperature and thereby the energy level in the combustion chamber (12) of an internal combustion engine (10), especially an HCCI-enabled  
5 internal combustion engine (10), with
- a compression device (16) to compress induced fresh air, which before compression has a temperature  $T_1$ , as well as
  - expansion means (18), which cause an expansion of the compressed induced fresh air,
  - 10 - where the compressed and subsequently expanded fresh air has a temperature  $T_2 > T_1$ ,

characterized in that,  
the temperature increase of the fresh air from  $T_1$  to  $T_2$  can be used to explicitly influence the temperature level and thereby  
15 the energy level in the combustion chamber (12).

2. System in accordance with claim 1,  
characterized in that,  
an exhaust gas recirculation device is provided to feed exhaust gas from an earlier combustion cycle to fresh air or  
20 to a mixture featuring fresh air, in order to provide an air/fuel/exhaust gas mixture with an advantageous energy level for combustion after injection of fuel.

3. System in accordance with claim 1 or 2,  
characterized in that,  
25 the compression device is an exhaust gas turbocharger (16).

4. System in accordance with one of the previous claims,  
characterized in that,  
the compression device is a compressor.

5. System in accordance with one of the previous claims, characterized in that, the expansion is performed on a throttle valve (18).

6. System in accordance with one of the previous claims, characterized in that, a temperature sensor (20) to record the temperature  $T_2$  is arranged in the direction of flow of the fuel/air mixture upstream from the expansion means, so that this can be taken into account within the framework of regulating the induction gas temperature.

7. System in accordance with one of the claims 2 to 6, characterized in that,

- at least one heat exchanger operating as an exhaust gas cooler (32) is provided for reducing the temperature of the recirculated exhaust gas, and
- a coolant setting valve (50) is provided, so that the induction gas temperature can be set or regulated by influencing the coolant throughflow through the exhaust gas cooler (32) taking into account measured values or values determined on the basis of technical models.

8. System in accordance with one of the previous claims, characterized in that, the exhaust gas cooler (32) is arranged in a separate heat exchanger circuit (46).

9. System in accordance with one of the previous claims, characterized in that, the exhaust gas cooler is arranged in an engine coolant circuit.

10. System in accordance with one of the previous claims,

characterized in that,  
the exhaust gas cooler is designed as an engine or  
transmission oil heat exchanger respectively.

11. System in accordance with one of the previous claims,  
5 characterized in that,  
the measured values or the values determined in accordance  
with technical models are assigned to at least one of the  
following variables:

- Exhaust gas temperature,
- 10 - Recirculated exhaust gas mass or quantity respectively,
- Air/fuel temperature,
- Air/fuel mass or quantity respectively,
- Induction gas temperature,
- Induction gas mass or quantity respectively,
- 15 - Coolant temperature or oil temperature of the coolant or  
oil flowing through the exhaust gas cooler and
- Coolant mass or oil mass or coolant quantity or oil  
quantity of the coolant or oil flowing through the exhaust  
gas cooler.

20 12. System in accordance with one of the previous claims,  
characterized in that,  
a temperature sensor (20) to record the air/fuel temperature,  
a temperature sensor (24) to record the exhaust gas  
temperature at the engine exhaust, an air mass or quantity  
25 measurement device respectively (28) to record the air/fuel  
mass or quantity and an exhaust gas mass or quantity measuring  
device (28) to record the exhaust gas mass or quantity are  
provided.

13. System in accordance with one of the previous claims,  
30 characterized in that,  
the induction gas temperature is calculated in accordance with

equation

$$T_{ASG} = \dot{m}_{FG} C_{p,FG} + \dot{m}_{AG} C_{p,AG}$$

, with

- 5  $\dot{m}_{FG}$ : Air/fuel mass flow  
 $\dot{m}_{AG}$ : Exhaust gas mass flow  
 $T_{FG}$ : Air/fuel temperature  
 $T_{AG}$ : Exhaust gas temperature  
 $T_{ASG}$ : Induction gas temperature  
10  $C_{p,FG}$ : Heat capacity of the air/fuel mixture  
 $C_{p,AG}$ : Heat capacity of the exhaust gas.

14. System in accordance with one of the previous claims,  
characterized in that,  
the exhaust gas temperature at the heat exchanger outlet is  
15 calculated using the following equation system:

$$|\Delta \dot{Q}_{KM}| = |\Delta \dot{Q}_{AG}| = \dot{Q}_{WT}$$

$$\Delta \dot{Q}_{KM} = \dot{m}_{KM} C_{p,KM} (T_{KM,OUT} - T_{KM,IN})$$

$$\Delta \dot{Q}_{AG} = \dot{m}_{AG} C_{p,AG} (T_{AG,IN} - T_{AG,OUT})$$

$$\dot{Q}_{WT} = kA\Delta T_m$$

- 20 with

- $\dot{Q}$ : Heat flow  
 $KM$ : Coolant  
 $AG$ : Exhaust gas  
 $WT$ : Heat exchanger  
25  $C_p$ : Heat capacity  
 $k$ : Heat transfer coefficient of the heat exchanger  
 $A$ : Heating surface of the heat exchanger

$\Delta T_m$  Mean logarithmic temperature difference.

15. Method for influencing the induction gas temperature and thereby the energy level in the combustion chamber (12) of an internal combustion engine (10), especially an HCCI-enabled  
5 internal combustion engine, in which

- induced fresh air, which before compression has a temperature  $T_1$ , is compressed and
- the compressed induced fresh air is expanded,
- with the compressed and subsequently expanded fresh air  
10 having a temperature  $T_2 > T_1$ ,

characterized in that,  
the temperature increase of the fresh air from  $T_1$  to  $T_2$  can be used to explicitly influence the temperature level and thereby the energy level in the combustion chamber (12).

15 16. Method in accordance with Claim 15,  
characterized in that,  
exhaust gas from an earlier combustion cycle is fed into fresh air or into a mixture featuring fresh air respectively, in order to provide, after fuel has been injected, an  
20 air/fuel/exhaust gas mixture with an energy level advantageous for combustion.

17. Method in accordance with claim 15 or 16,  
characterized in that,  
the compression is performed by an exhaust gas turbocharger  
25 (16).

18. Method in accordance with one of the Claims 15 to 17,  
characterized in that,  
the compression is performed by a compressor.

19. Method in accordance with one of the Claims 15 to 18,  
characterized in that,  
the expansion is performed on a throttle valve (18).

20. Method in accordance with one of the claims 15 to 19,  
5 characterized in that,  
the temperature  $T_2$  is recorded after the expansion, so that  
this can be taken into account within the framework of a  
regulation of the induction gas temperature.

21. Method in accordance with one of the claims 16 to 20,  
10 characterized in that,

- exhaust gas is cooled in a heat exchanger operating as an  
exhaust gas cooler (32) for reducing the temperature of  
the recirculated exhaust gas, and
- by influencing the coolant throughflow through the exhaust  
15 gas cooler (32) by means of a coolant setting valve (50)  
taking into account measured values or values determined  
from technical models, the induction gas temperature is  
set or regulated respectively.

22. Method in accordance with Claim 21,  
20 characterized in that,  
the measured values or the values determined in accordance  
with specific models are assigned to at least one of the  
following variables:

- Exhaust gas temperature,
- 25 - Recirculated exhaust gas mass or quantity respectively,
- Air/fuel temperature,
- Air/fuel mass or quantity respectively,
- Induction gas temperature,
- Induction gas mass or quantity respectively,
- 30 - Coolant temperature or oil temperature of the coolant or

oil flowing through the exhaust gas cooler and  
 - Coolant mass or oil mass or coolant quantity or oil  
 quantity of the coolant or oil flowing through the exhaust  
 gas cooler.

5 23. Method in accordance with claim 21 or 22,  
 characterized in that,  
 the air/fuel temperature, the exhaust gas temperature at the  
 engine exhaust, the air/fuel mass or quantity respectively and  
 the exhaust gas mass or quantity respectively are measured.

10 24. Method in accordance with one of the claims 21 to 23,  
 characterized in that,  
 the induction gas temperature is calculated in accordance with  
 equation

$$15 \quad T_{ASG} = \dot{m}_{FG} C_{p,FG} + \dot{m}_{AG} C_{p,AG}$$

$\dot{m}_{FG}$ , with Air/fuel mass flow

$\dot{m}_{AG}$  Exhaust gas mass flow

$T_{FG}$ : Air/fuel temperature

20  $T_{AG}$ : Exhaust gas temperature

$T_{ASG}$  Induction gas temperature

$C_{p,FG}$ : Heat capacity of the air/fuel mixture

$C_{p,AG}$ : Heat capacity of the exhaust gas.

25 25. Method in accordance with one of the claims 21 to 24,  
 characterized in that,  
 the exhaust gas temperature at the heat exchanger outlet is  
 calculated using the following equation system:

$$|\Delta \dot{Q}_{KM}| = |\Delta \dot{Q}_{AG}| = \dot{Q}_{WT}$$

$$\Delta \dot{Q}_{KM} = \dot{m}_{KM} C_{p,KM} (T_{KM,OUT} - T_{KM,IN})$$

$$\Delta \dot{Q}_{AG} = \dot{m}_{AG} C_{p,AG} (T_{AG,IN} - T_{AG,OUT})$$

$$\dot{Q}_{WT} = kA\Delta T_m$$

with

- $\dot{Q}$ : Heat flow
- 5  $KM$ : Coolant
- $AG$ : Exhaust gas
- $WT$ : Heat exchanger
- $C_p$ : Heat capacity
- $k$ : Heat transfer coefficient of the heat exchanger
- 10  $A$ : Heating surface of the heat exchanger
- $\Delta T_m$  Mean logarithmic temperature difference.